Cairo Air Improvement Project

Lead Pollution Abatement Component

Contamination Assessment of the Awadallah Secondary Lead Smelter at Shoubra El Kheima

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USAID/Egypt, Office of Environment

USAID Contract No. 263-C-00-97-00090-00

May 2003

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1. INTRODUCTION

The Government of Egypt (GOE) through the Egyptian environmental Affairs Agency (EEAA) has developed a comprehensive plan for lead abatement in Cairo. The EEAA Lead Exposure Abatement Plan (LEAP) addresses all sources, exposure pathways and remedial actions associated with lead pollution in the Greater Cairo Area. As part of this plan, secondary lead smelters that are located in densely populated areas have come under increased scrutiny. The GOE developed the Lead Smelter Action Plan (LSAP) to reduce the impact of these lead smelters on the environment.

As part of the LSAP, the Cairo Air Improvement Project (CAIP) and Egyptian Environmental Policy Project (EEPP) are currently working with the Awadallah family's company, a major lead producer in Cairo, to consolidate its operations and move them to a new, more modern plant site located at the Abu Zaabal Industrial part. This move will leave in its wake the existing structures which have become highly contaminated with lead dust. Towards developing a long-term solution to remediate at least one smelter site and reducing environmental and human health risks, CAIP and EEPP are evaluating the hazards and developing a remediation program for Awadallah's Secondary Lead Smelter at Shoubra El Kheima .

To date, much work has been completed on the site. A "Preliminary Assessment" has been completed evaluating the site in terms of its potential to pose risks to people and the environment. During this assessment, soil and water "grab" samples were taken and an analyzed for various contaminants and conclusions were drawn on a preliminary basis as to the levels of metal contamination on the site. With the completion of this assessment, a more detailed soil and dust sampling program took place as part of what is known as a "Remedial Investigation" (RI). With time, the data collected during this investigation will be the basis for long-term remediation planning for the site.

The following presents a brief overview of background information for the Smelter including existing site conditions and the findings and conclusions of the "Preliminary Assessment." In addition, the methodologies, results, and conclusions are presented for the Remedial Investigation to date.

2. BACKGROUND

2.1. The Smelter

This smelter began operations in 1979 and ceased smelting in August, 2001. The main raw material for the plant was used batteries. Approximately, 20,000 tons of batteries were recycled per year producing 11,000 tons of lead ingots. The smelter has area of approximate 1550 m^2 with a total volume of building material of about 553 m^3. After the smelting process stopped, the plant was used only in refining and manufacturing lead products. Few environmental controls were in place at the workplace to prohibit the dust and molten lead from coating the floors or walls of the smelter.

The site where the smelter is located is within the flood plain of the Nile River. The topography of the area is almost flat with an average altitude of 17 meters above mean sea level. The climate of the site is considered arid. Annual rainfall is about 25 mm/year. The wind direction at the site is primarily from the North. The smelter lies within a mixed industrial and residential area. The site is located approximately about 40 meters north of a soccer field, and about 30 meters east of housing block. Underlying the smelter, there are two hydrogeologic units, an upper silt and clay layer and a major alluvial aquifer. The water table is between 5 – 6 meters below the ground surface. Two hundred meters to the south of the site is the Ismalia Canal, which is a source of recharge to the aquifer.

2.2. The "Preliminary Assessment"

As part of the "Preliminary Assessment " of the Awadallah smelter site, a field investigation was performed to determine the nature of the potential hazards to human health and the environment at the site. These studies were performed by CAIP personnel and IWACO Egypt to determine the following:

- A preliminary estimate as to the size and volume of building material and equipment that may have to be removed or remediated.
- If dust and soils at the site has been contaminated due to activities at the site.
- If the groundwater or surface water has been contaminated due to activities.
- If there are other sources of contamination in the area which may contribute to pollution of water or air.

These studies were performed using QA/QC (quality assurance/quality control) protocols.

The results of this study indicated that the smelter poses a multitude of health and safety hazards to remediation workers, nearby residents, and the environment. Exposure to toxic elements associated with batteries such a lead, cadmium, arsenic, antimony, and selenium can have a profound effect on long-term human health. Children and young adults playing near or within the smelter grounds can be exposed to lead through inhaling or ingesting high levels of contaminated fugitive dust. Fugitive dust from the smelter could be blown and deposited on agricultural products; onto the waters in the Ismalia Canal; and on the water treatment plant of Amiriya which is located about 300 meters downwind of the smelter. Safety hazards also exist to workers and to children playing within site boundaries.

Of the contaminants found at the site, lead is of most concern. Lead ingots, and other products. Lead exposure affects many organ systems, including cardiovascular, renal, and hepatic. The most sensitive is the central nervous system, particularly in children. Lead also damages kidneys and the immune system. Unborn children can be exposed to lead through their mothers. Harmful effects include premature births, smaller babies, decreased mental ability in the infant, learning difficulties, and reduced growth in young children.

High lead and other metals were found at high levels in dust samples, soil samples, and water samples at the site. Dust samples taken from the floor of the site showed up to 33% lead. Soil samples showed up to 2.4% lead in the upper 0.5 meters above background levels to below water table as illustrated in Figure 2.1 (see Figure 2-2 for borehole locations). Groundwater sampling from wells drilled on and near the site showed the following:

> Antimony, selenium, and arsenic were not detected in the samples;
> Traces of cadmium were found in three samples; and
> Lead was found, and exceeded the drinking water limits (>0.5 mg/L) in all samples posing a hazard to human health if consumed directly.

Figure 2-1: Concentration of Lead with Depth – Awadallah Lead Smelter

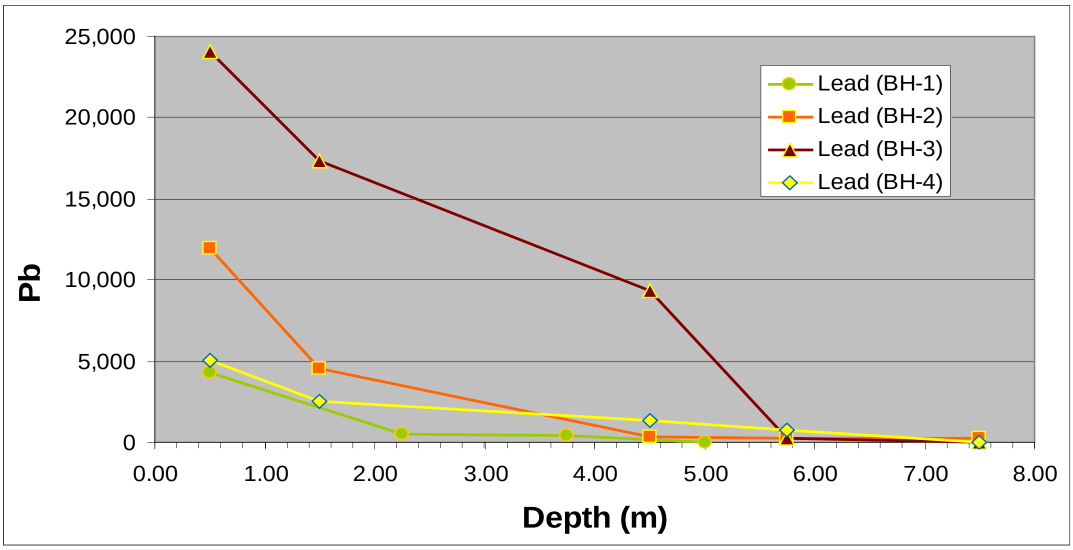
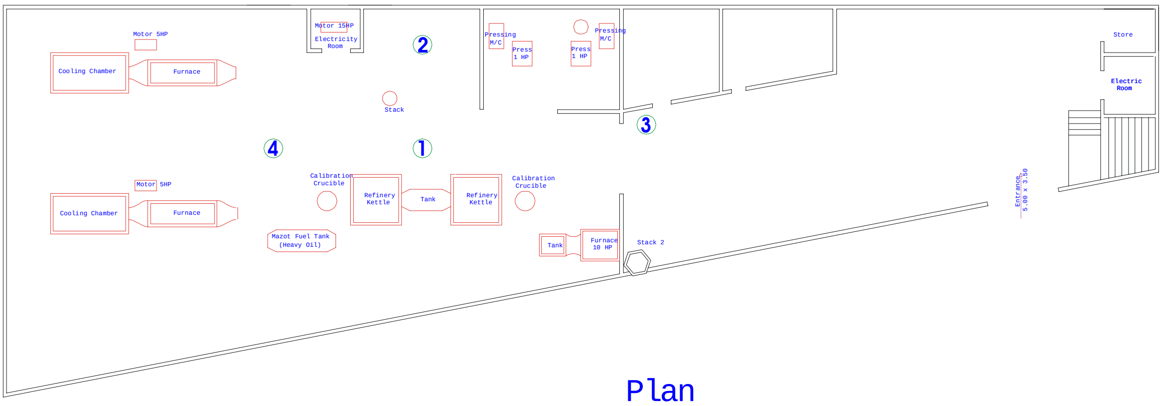


Figure 2-3: Borehole Well Location Map- Awadallah Secondary Lead Smelter



Plan

In general, there are three potential pathways by which contaminants such as lead, can reach potential receptors and the environment due to releases from the smelter. These are:

1. Air through the dispersion of fugitive dust;
2. Water through storm water runoff, fugitive dust depositing on waterway, and migration of leacheate to groundwater; and
3. By direct contact with contaminated dust and soil.

For this assessment, each of these was evaluated on a preliminary bases. It was determined that the dispersion of contaminated fugitive dust by wind and direct contact were the principal pathways of concern. With residents living nearby and directly to south (the prevailing wind direction) and workers at the site being the most at risk.

Findings from this assessment indicated that actions presented in the remediation plan for the site should include at a minimum the following:

The removal of contaminated dust from the floors, walls, and ceiling of the smelter site.

The cleaning of recyclable material and removal from the site this includes the corrugated steel roof of the building, the stack, and machinery.

The removal of all contaminated material or the encapsulation of the building's site in concrete.

Exposed contaminated soil down to at least one meter below ground surface should be removed.

Access to site should be controlled whether the smelter is demolished or left in place.

Fugitive dust and direct contact with contaminants at the site should be controlled at the site.

Groundwater and surface water remediation at this time is not recommended but a monitoring plan should be developed.

Finally, it was concluded that additional sampling of soil and dust had to be completed at the site in order to present a detailed report indicating the levels of contamination at the site.

3. SOIL AND DUST SAMPLING

As part of the Remedial Investigation, soil and dust samples were collected on 17 April 2003 using two methods. The first method consisted of collecting bulk dust and soil samples from the floor and in the direct vicinity of the smelter. The second involved using wetted wipe cloths to collect dust samples from walls, tiled and carpeted floors, duct work, window ledges, and other relatively smooth surfaces. Prior to sampling, a Sampling and Analysis Plan (SAP) as presented in Appendix A was developed for the site. In addition, a Health and Safety course was presented to samplers and a Lead Technician training course was given to all interested participants. In general, the following procedures were used for bulk sampling and wipe sampling.

3.1. Bulk Sampling

As part of the SAP, a sampling grid for the entire site was laid out on a plan drawing of the smelter and just outside the plant as a guide. It was anticipated that at least 20 to 40 samples would be taken. Figure 3-1 shows the final 25 sampling locations. Soil samples were labeled with “S” and dust samples, from the concrete, were labeled with “D”. In general, the samples were taken using a small shovel and fine brush. It was felt that the larger the sample the better but at least 200 grams should be collected at each sampling location. The portion of concern was that which would pass through a 250 micron screen. During sampling the following steps were followed:

1. At each sampling site, the sampler placed on a pair of clean plastic gloves, facial masks and white lab coats.
2. Using a measuring tape and a clean, stainless steel spoon, a small test hole was dug adjacent to the sampling location to a depth of 1.5 cm to act as a visual aid during soil collection to help limit collection to a depth of 1.5 cm.
3. Soil samples were placed into a plastic bag with the spoon or troll down to the depth indicated by the test hole and samples were collected until a circular hole of approximately 5 cm diameter was created.
4. Soil samples were collected from two more locations within a 0.3 m diameter circle around the first sample location using the same procedure as given above.
5. Samples were composited in the same plastic bag.
6. Soil bags were labeled.
7. Gloves were discarded into a trash bag after all scoop samples were collected and composited.

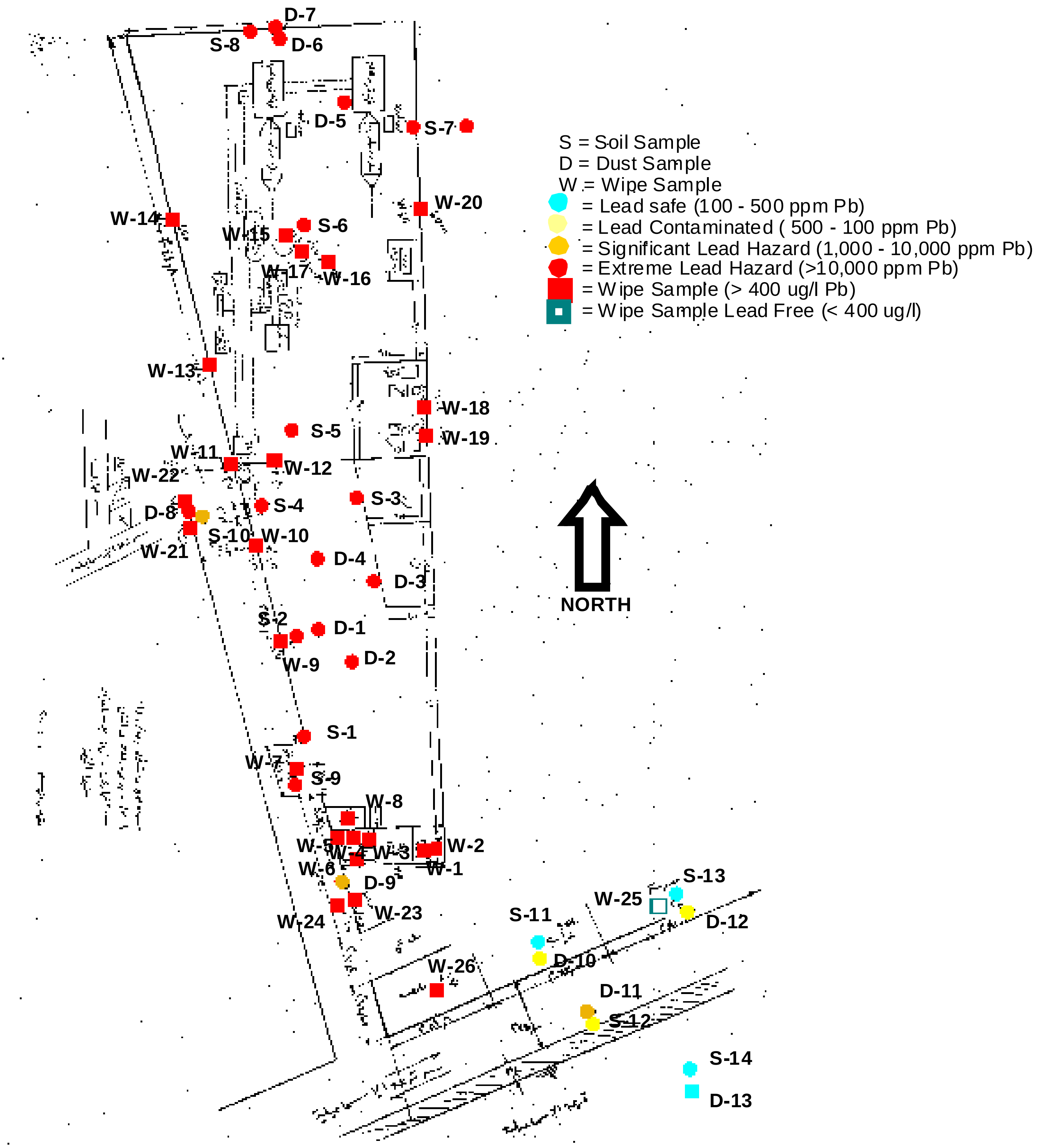


Figure 3-1: Soil and Dust Sampling Location (Not to Scale)

8. Samples were placed on ice and chain-of-custody forms filled in.
9. Sampling equipment was cleaned with a disposable wipe or soap/ water.
10. The samples were sent to the laboratory for analysis.

For areas where the soil is hard, a garden troll was used to dig out the 5 cm diameter, 1.5 cm hole.

For dust samples, similar procedures were used within the 0.3 m circles, except that a new brush was used every time to gather the dust which was then placed into plastic bags.

All analyses in the Laboratory were performed according to US EPA METHOD 3050 B “Acid Digestion of Sediments, Sludges, and Soils”

3.2. Wipe Samples

Wipe samples were taken from floors - smooth concrete, tile or carpeted, interior walls, window sills and troughs, roofing materials, duct tubes for filtration, machinery, and other smooth surfaces. All were collected and analyzed according to ASTM E1728, ``Standard Practice for Field Collection of Settled Dust Samples Using Wipe Sampling Methods for Lead Determination by Atomic Spectrometry Techniques” , or equivalent method, with an acceptable wipe material as defined in ASTM E 1792, ``Standard Specification for Wipe Sampling Materials for Lead in Surface Dust”.

In general, wipe samples consists of using a wetted disposable cloth to wipe an area 30 cm by 30 cm. For this purpose, a template was made. At the site, 26 wipe samples were taken. The wipe sample locations labeled “W” are presented in Figure 3-1. During wipe sampling, the following procedures were used at each sample location:

1. The template was placed on the surface to be sampled.
2. Plastic sample collection tubes were labeled and prepared.
3. The sampler placed clean latex gloves and removed a disposable wipe from its container.
4. Using an S-motion, the sample area was wiped up and down and then side to side until the whole area was covered.
5. The sample was placed in the labeled tube, sealed, placed on ice and chain-of-custody forms were filled in.
6. Gloves and other used material were disposed of.
7. The samples were sent to the laboratory for analysis.

4. THE RESULTS

The results of the analysis of the soil and dust samples are presented in Table 4-1. As a guide to various action levels for lead clean-up, values are color coded according to the guidelines presented in Table 4-2. It should be noted that because action levels for various degrees of contamination have not been developed in Egypt at this time, the guidelines presented in Table 4-2 based on the U.S. State of Rhode Island are only considered as a point of reference.

For the other metals, currently there are few guidelines for total concentration of cadmium, zinc, chromium, selenium, arsenic, and antimony in soils. Standards are for the most part in the United States are based on analyses performed using US EPA method 1311 Toxicity Characteristic Leaching Procedure (TCLP) tests. Such tests were performed on smelter's waste slag in 1998 (Osborn, 1998) to determine if this material was "hazardous" or "toxic". These tests indicated that the slag was "non-hazardous". Assuming that the soil and dust within the plant are similar to the slag, this indicates that these would also be considered "non-hazardous".

Table 4-1: Chemical analysis of Dust and Soil Samples Collected from Awadallah Secondary Lead Smelter at Shoubra ELKheima

Sample No.	Pb mg/Kg	Se mg/Kg	As mg/Kg	Sb mg/Kg	Cr mg/Kg	Zn mg/Kg	Cd mg/Kg
S-1	80137.5	N.D	164.5	822.5	N.D	899.75	2.75
S-2	140000	N.D	166	1519.75	N.D	841.74	9.5
S-3	329912.5	N.D	205.75	4278	N.D	1087	2.5
S-4	340825	N.D	227.75	10282	N.D	962.75	5.5
S-5	671025	N.D	184	3920.5	N.D	392.5	N.D
S-6	669925	N.D	152.5	2919	N.D	352.5	1.5
S-7	28787.5	N.D	N.D	893	N.D	99	N.D
S-8	782625	N.D	2130	28801.5	N.D	308.5	2.5
S-9	43100	N.D	N.D	552.25	N.D	1220.5	N.D
S-10	4126.25	N.D	N.D	54.25	N.D	226.75	N.D
S-11	398.25	N.D	N.D	3.5	N.D	181	N.D
S-12	600	N.D	N.D	.25	N.D	266.5	N.D
S-13	462	N.D	N.D	1.25	N.D	622.25	0.25
D-1	175000	N.D	198	2346	11.25	1469.3	6
D-2	146075	N.D	277.5	4992	221.25	6691.5	2.5
D-3	275925	N.D	272.5	3598	338	2463.5	6.5
D-4	215712.5	N.D	392.5	3359.75	32.25	1096.5	0.5
D-5	653650	N.D	248.5	8008.5	N.D	1985.5	N.D
D-6	679100	N.D	825	20925	N.D	1439	N.D
D-7	603575	N.D	152	11365	N.D	588.5	N.D
D-8	19637.5	N.D	N.D	291	N.D	1454.5	1.25
D-9	5350	N.D	N.D	16.5	N.D	849	0.25
D-10	672	N.D	N.D	3.75	N.D	206	0.5
D-11	1758.75	N.D	N.D	18.75	N.D	408	1.75
D-12	802.5	N.D	N.D	101.5	N.D	700	3.25
S-14	228.75	N.D	N.D	22	N.D	177.75	N.D
D-13	279	N.D	N.D	18.25	N.D	228	N.D

Table 4-2: Lead Contaminated Guides based on State of Rhode Island Guidelines

0-150 ppm – Lead-Free Standard. These soils are considered lead-free and do not pose a risk to people, or require any remediation measures.
150-500 ppm - Lead-Safe. These soils are generally considered safe for older children and adults. If small children who eat more dirt than others or absorb lead easily use these properties are present, efforts to make such premises Lead-Free are suggested.
500-1,000 ppm – Lead Contaminated – These soils require efforts to keep the contaminated soil covered with at least 8 cm of lead-free soil.
1,000-10,000 ppm – Significant Environmental Lead Hazard. Management of hazards would include covering the soil with concrete, asphalt or any other permanent cover or soil removal and disposal.
Above 10,000 ppm – Extreme Environmental Lead Hazard. Excavation and removal of material would be required.

The results of the lead wipe samples are presented in Table 4-3. As a guideline, those values exceeding United States Environmental Protection Agency clearance standards for floors, interior window sills, and troughs to 40, 250, and 400 µg/900cm^2, respectively are shaded in red.

Table 4-3: Lead Content in Wipe Samples - Awadalla's Lead Smelter

µg Pb /wipe	Sample NO.	µg Pb /wipe	Sample NO.
6476.5	W1	758625	W16
11307.5	W2	537250	W17
1625.5	W3	141862.5	W18
17867.5	W4	174412.5	W19
1633.5	W5	305687.5	W20
9997.5	W6	12807.5	W21
12775	W7	1831.75	W22
18915	W8	458.25	W23
39965	W9	518.25	W24
12280	W10	106.5	W25
43027.5	W11	1918.5	W26
100825	W12	8.99	blank
696750	W13	97.98 %	L.C.S recovery
1129750	W14	98.129%	L.C.S.D recovery
14190	W15		

5. DISCUSSION OF THE RESULTS

Data from the bulk dust and soil sampling are summarized in Tables 5-1 and 5-2. As presented in Table 5-1, the results indicate that all of the samples analyzed for lead within the boundaries of the smelter building are considered according to the U.S. State of Rhode Island Standards as posing an extreme environmental lead hazard. According to these guidelines, remediation of the site would require that the majority of the material be removed and disposed of in a regulated landfill. The concentrations of lead at the site were in the rang of 4126.25 mg/Kg and 782625 mg/Kg, amounting to an average of 275025.49 mg/Kg, which is 27% lead. As illustrated in Figure 3-1, the highest concentrations of lead appear to be in soil samples S-5, S-6, and S-8 and dust samples D-5 and D-6 in the northern sector of the smelter.

Table 5-1: Metal Analysis Summary – Samples Taken within Awadallah Lead Smelter

Sample No.	Pb mg/Kg	Se mg/Kg	As mg/Kg	Sb mg/Kg	Cr mg/Kg	Zn mg/Kg	Cd mg/Kg
Mean	325507.71	N.D.	399.75	6051.56	150.69	1309.96	3.73
Maximum	782625.00	N.D.	2130.00	28801.50	338.00	6691.50	9.50
Minimum	4126.25	N.D.	152.00	54.25	11.25	99.00	0.50
Std. Dev.	275025.49	N.D.	527.38	7701.19	156.56	1482.13	2.76
N*	18	0	14	18	4	18	11

N* = number of samples above detection limits N.D. =Not detected

Table 5-2: Metal Analysis Summary – Samples Taken Outside Near the Awadallah Lead Smelter

Sample No.	Pb mg/Kg	Se mg/Kg	As mg/Kg	Sb mg/Kg	Cr mg/Kg	Zn mg/Kg	Cd mg/Kg
Mean	1172.36	N.D	N.D	20.63889	N.D	404.2778	1.2
Maximum	5350	N.D	N.D	101.5	N.D	849	3.25
Minimum	228.75	N.D	N.D	0.25	N.D	177.75	0.25
Std. Dev.	1631.86	N.D	N.D	31.49879	N.D	255.7571	1.30384
N*	9			9		9	5

N* = number of samples above detection limits N.D. =Not detected

For those samples taken outside the building (S-10 - S-13, D-9 – D-12) , downwind, concentrations with the exception of soil samples S-11 and S-13, the dust and soil samples are considered either being lead contaminated or a lead hazard. These samples range in concentration between 228.75 mg/Kg, taken south of the Ismalia Canal, and 5350 mg/Kg, taken just west of the smelter building. The mean concentration of these samples is 1172.36 mg/Kg. In general, these values are especially alarming since these samples were taken in areas such as a football field where children's health could be adversely affected. Concern should be voiced if proper steps are not taken to remediate the site.

Lead wipe samples also indicate, a high level of lead contamination of walls, floors, duct work, machinery and other parts of the building. Lead concentrations exceed US EPA standards for all samples taken within the smelter building. This indicates that all material in the building should be handled carefully during remediation. Outside the building, wipe samples of nearby residential structures also showed high levels of lead. The only exception was sample W-25 which is outside the smelter building. Admittedly the analysis of these samples are compared to a relatively strict standard for household, the high concentrations samples both within and outside the smelter indicates that there is a high risk to human health from dust exposure in and outside the smelter.

For the other metals analyzed at the site, concentrations of chromium arsenic, antimony, and to some extent cadmium, indicate that lead is not the only contaminant of concern at the site. These contaminants as mentioned could pose a human health risk by exposure to dust, through dermal contact, inhalation, and other exposure pathways. The results reveal that the highest concentrations for antimony and arsenic in the soil were exhibited in S-8, being 28801.5 mg/Kg and 2130 mg/Kg respectively. As for the dust samples; antimony and arsenic were highest in sample D-6, amounting to 20925 mg/Kg for the former and 825 mg/Kg for the latter. It is important to mention here, that both samples S-8 and D-6 are in the same location inside the smelter. Zinc concentrations were highest in sample D-2, being 6691.5 mg/Kg.

6. CONCLUSIONS

The new data collected for the soil and dust samples, reconfirm the results of the "Preliminary Assessment" that was carried out previously at the site. These include:

1. With lead concentrations as high as 78% lead, the site is considered to be heavily contaminated with lead and other metals.
2. Lead soil and dust samples taken within the smelter are considered to pose an extreme environmental hazard.
3. Wipe samples indicate that all walls, floors, duct work, machinery and other surfaces in the building are contaminated with lead dust.
4. Dust and soil samples taken directly outside the building on nearby streets, play areas, on buildings, and other structure show varying levels of lead contamination and indicate that lead hazards exist outside the smelter area.
5. Other metals including chromium, cadmium, antimony and arsenic found in contaminated dust, soil, and surfaces could pose potential health risks to workers and nearby residents.
6. Although not evaluated in this report, there is concern for surface water and groundwater as pathways. However, because the Ismalia Canal, which recharges the shallow aquifers at the site, is already contaminated above drinking water standards, and numerous wells exist in the up and down gradient have exhibited high lead concentration, it is not possible at this time to determine what percentage of this contamination is directly attributed to the smelter.

During the Risk Assessment Phase and the Remedial Design Phase of this project, a groundwater monitoring program will be implemented and the groundwater pathway will be evaluated in more detail. As part of this program a Sampling and Analysis Program will be developed so that each sampling run will be consistent. For the Remedial Design, additional soil samples may be required and additional boreholes will be drilled within the Smelter area.

The level of contamination found in the site due to the smelting process of lead is found to be extremely high and is considered to be hazardous to all the workers and residents in the neighborhood. Therefore we recommend that the smelting process of lead should be prohibited immediately be law.

7. REFERENCES

ASTM, 2002, E1728-02, ``Standard Practice for Field Collection of Settled Dust Samples Using Wipe Sampling Methods for Lead Determination by Atomic Spectrometry Techniques."

ASTM, 2002, E 1792-02,``Standard Specification for Wipe Sampling Materials for Lead in Surface Dust."

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